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U. S. NAVAL AIR DEVELOPMENT CENTER

JOHNSVILLE, PENNSYLVANIA

Aeronautical Electronic and Electrical Laboratory

REPORT NO. NADC-EL-L6285 16 JAN 1963

EVALUATION OF DEVELOPMENTAL HIGH TEMPERATURE PULSE FORMING NETWORK, Z-2922 MANUFACTURED BY SPRAGUE ELECTRIC COMPANY NORTH ADAMS, MASSACHUSETTS

PHASE REPORT
WEPTASK NO. RAV03J001/2021/R008-01-01
Problem No. 22

U. S. NAVAL AIR DEVELOPMENT CENTER
JOHNSVILLE, PENNSYLVANIA

IN REPLY REFER TO:
EL-56
389
16 Jan 1963

From: Commanding Officer, U. S. Naval Air Development Center, Johnsville, Pennsylvania
To: Chief, Bureau of Naval Weapons

Subj: Report No. NADC-EL-L6285, "Evaluation of Developmental High Temperature Pulse Forming Network, Z-2922, Manufactured by Sprague Electric Company, North Adams, Massachusetts," (Phase Report, WEPTASK No. RAV03J001/2021/R008-01-01, Problem No. 22)

Ref: (a) BUWEPS ltr RAAV-4423/41 of 9 Feb 1961
(b) BUSHIPS Contract Spec No. H-3199, "High Temperature (150°) Pulse Forming Network" of 1 Oct 1958
(c) BUSHIPS Modification No. 4 to Contract NObsr-77598, of 25 Apr 1962
(d) Sprague Electric Company Final Report, "Development of High Temperature Pulse Forming Network under Contract No. NObsr-77598" of 30 Jul 1962

1. WEPTASK No. RAV03J001/2021/R008-01-01, Problem No. 22, established by reference (a), requested that an evaluation be made of a developmental, high temperature, pulse-forming network Z-2922, manufactured by the Sprague Electric Company, North Adams, Massachusetts, for the Bureau of Ships under Contract No. NObsr-77598. The network was developed as a result of a joint BUWEPS and BUSHIPS program of standardization and improvement of pulse-forming networks. The objective of the contract was to develop techniques for the design and fabrication of pulse-forming networks capable of continuous operation at ambient temperatures between -55 and +150° C; moreover, the networks must be designed so that they will not evolve hydrogen or other explosive gases when subjected to sustained arcing during breakdown.

2. One sample pulse-forming network developed by the Sprague Electric Company was delivered to the U. S. Naval Air Development Center (NAVAIRDEVCEN). The network uses a fluorinated hydrocarbon fluid as a dielectric fluid. This fluid contains no hydrogen and does not evolve explosive gases under sustained arcing or conditions of high electrical stress. The dielectric of the capacitors in the network is mica paper. This mica paper is completely inorganic and presents no explosion hazard. The fluorinated hydrocarbon dielectric fluid has a high temperature coefficient of expansion that can result in high case pressures when operated

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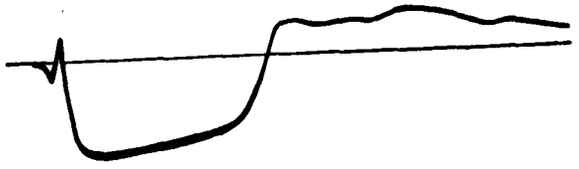
over the complete temperature range. To compensate for this, the Sprague Electric Company incorporated a separate expansion compartment with a silicone rubber diaphragm to permit fluid expansion and maintain a relatively constant fluid pressure. Because of the high temperature coefficient of expansion and the inability of the networks to operate over the entire temperature range, the 150° C requirement of reference (b) was subsequently reduced to 125° C by reference (c). The networks were designed to meet the electrical requirements of the AN/APS-45 radar system.

3. The sample network was evaluated for conformance with the requirements of references (b) and (c). The network met all of the specification requirements except for pulse waveform. A parasitic oscillation appeared on the leading edge of the pulse waveform. This oscillation affected the pulse shape to the extent that accurate pulse shape measurements could not be made. The parasitic oscillation was as follows:



4. Comparing the standard AN/APS-45 pulse-forming network in the modulator circuit with the sample network indicated that the parasitic oscillation was present only in the sample network. Principally, parasitic oscillations result from impedance mismatches. Many times these mismatches are caused by stray inductances and capacitances. In this particular case where the active volume of the network was reduced by the incorporation of the expansion compartment, it is possible that the

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internal strays, which differed from those in the standard network, could have been responsible for the impedance mismatch. Because no data were reported in reference (d) on impedance measurements of the network, or measurement and calculations of stray inductances or capacitances, it was not possible to come to any definite conclusion. Since an operating AN/APS-45 system was not available at NAVAIRDEVCEN, it was not possible to determine the effects of the parasitic oscillation on the system operation.

5. Reference (d) indicated that the network design consisted of a four mesh "E" type line using a single layer solenoid coil appropriately tapped for the necessary connections to each of the four meshes. Each of the four meshes contained 12 series connected capacitors. Although this arrangement lowers the corona and dielectric strength requirements for each capacitor, it does not readily permit detection of network failure. For example, if one capacitor broke down, the total network capacitance change would be less than 2.5 percent. This change could not be detected in the system operation and could not be detected by capacitance measurement because it is within the capacitance tolerance for the network. Continuous operation in this condition, and the decomposition of the dielectric fluid, could cause pressure increase in the case, rupture of the diaphragm, leakage of fluid into the expansion compartment, and ultimate reduction of the dielectric strength of the other capacitors and their ultimate failure. If a different mesh arrangement were used, one that might change the network capacitance by 25 percent, network failure could be noted by change in system performance. In this case, however, the corona and dielectric strength problems would be increased so that an ideal solution would have to be a compromise.

6. The use of an expansion chamber and a volume compensating diaphragm is an innovation in the manufacturing of pulse-forming network; therefore, little information is available on its reliability. Malfunction of the diaphragm can not be detected directly. It can be determined only after total network failure.

7. The following conclusions were derived from the evaluation of the sample network:

a. The appearance of parasitic oscillation in the pulse waveform prevented the sample network from meeting the electrical requirements.

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b. The manufacture of a pulse-forming network using nonexplosive materials is possible. However, the high temperature coefficient of expansion of suitable dielectric fluids makes it necessary that volume compensating devices be used to achieve satisfactory operation over fairly wide temperature ranges.

c. The reliability of the volume compensating diaphragm used by the manufacturer has not been established. This device should be investigated further before it is accepted for service use. With the exception of the volume compensating diaphragm, it is felt that the techniques used in the construction of this network are usable in networks of smaller volume where the fluid expansion would not present such a great problem.

d. The design of the capacitor mesh arrangement in the network is such that failure of an individual capacitor would not be detected during system operation or by capacitance measurement.

8. In view of the fact that the sample network did not meet the electrical requirements of reference (b), the use of this particular network as a replacement for the one used in the AN/APS-45 is not recommended. It is further recommended that efforts be made to find a suitable fluorinated hydrocarbon dielectric fluid with a lower temperature coefficient of expansion for use in pulse-forming networks, or a suitable, reliable volume compensating device be developed.

9. Problem No. 22 of WEPTASK No. RAV03J001/2021/R008-01-01 will be held open pending completion of the final report on the overall problem. The sample network is being retained at NAVAIRDEVCEN.

D. W. MACKIERNAN
By direction

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Problem No. 22

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